Enhanced Color Image Segmentation of Foreground Region using Particle Swarm Optimization

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ABSTRACT

This paper proposes a new segmentation approach which aims to segment only the foreground of an image after background elimination. Background elimination is treated as an optimization problem and is solved by using principle of PSO. The proposed algorithm is a thresholding method used to eliminate background from an image assuming that the image to be threshold contains two classes of pixels or bi-modal histogram(foreground and background). This gives a low level binary representation to the image eliminating the background and highlighting the foreground part. Based on the distance and similarity among the connected components in the binary image, it is segmented and a different similar color is assigned to each of the segment to preserve the color information contained in the real color image.

Keywords- Thresholding; Background Elimination; Segmentation; Feature Extraction; Particle Swarm Optimization.

1. INTRODUCTION

Segmentation is the process of partitioning a image into multiple segments (sets of pixels) .Segmentation aims to simplify and/or change the representation of an image into something that is more meaningful and easier to analyze [1]. Image segmentation is used to locate objects and boundaries (lines, curves, etc.) in images by assigning a label to every pixel in an image such that pixels with the same label share certain visual characteristics [2].

Each of the pixels in a region is similar with respect to some characteristic or computed property, such as color, intensity texture [3][4] . Adjacent regions are significantly different with respect to the some characteristics. Some of the image segmentation techniques are thresholding technique, clustering methods and histogram based segmentation [4].

Thresholding based segmentation is one of the most effective approach used in image segmentation. . It is classified into two groups local and global thresholding approach [4]. Thresholding technique is used to compute a threshold for bi-level thresholding and to differentiate the background and the foreground [2]. Choice of a appropriate threshold is very important in any thresholding technique [3]. Histogram shape-based image thresholding technique has been used for the reduction of an image to a binary image. Variance among the strength of the pixels corresponding to various intensity levels is computed which is optimized by PSO. This optimized variance is used as a threshold for the binary differentiation of the background and the foreground (region of the interest). Now the binary threshold image is segmented into regions based on the connected component strength among the pixels.

PSO has been used as to search an optimum threshold as it is an intrinsically non-deterministic search algorithm which is based on the behavior of bird flocking [5]. PSO has been successfully used in various domains as a method to deal with optimization problem including in the image processing fields such as for image segmentation [6]. Image segmentation is a task of partitioning an image into various homogeneous regions [4].

Image segmentation can be dealt as a clustering method [4].As clustering is a process of grouping a set of data objects into multiple groups or clusters so that object within a group have a high degree of similarity, but are very dissimilar to objects in other clusters[8].Thus in image segmentation it is a process of assigning a label to every pixel in an image such that pixels with the same label share certain visual characteristics and are in a segment.

Lot of research work has been proposed in the field of image segmentation. Such as segmentation using *fuzzy sets* [9] which assigns a fuzzy representation to a zone of similar pixels in an image based on non uniformity of color distribution .*Entropy based segmentation methods* [10][11] in which threshold for segmentation is computed by entropy thresholding ,minimum cross entropy has been used in [10] where as maximum entropy has been used in [11] as a threshold. *Multi level thresholding segmentation* [12][13] which uses PSO for calculation of optimal threshold. But in all these approaches foreground and background are dealt together, due to which background is also segmented along with the foreground. This problem of background segmentation is taken into account in the present work, as in *graph based approach* [14] (for segmentation of old stone carved images to enhance the work of an OCR). Thus enhancing the segmentation of the object of interest in an image. Proposed work has been carried out in three phases which are preprocessing phase, background elimination phase and finally the segmentation phase.

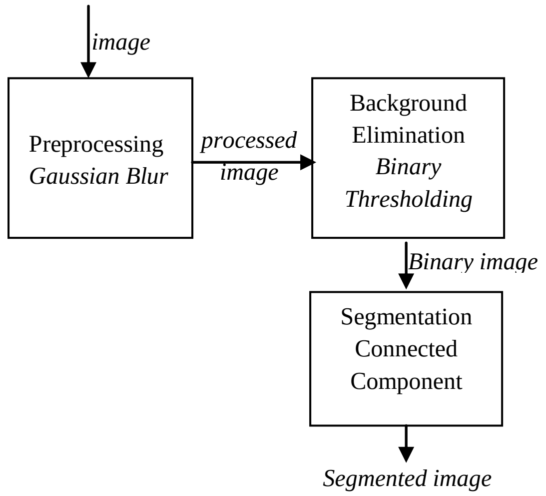


Fig 1: Block diagram of stages in segmentation of a image.

2. METHODOLOGY

2.1 Preprocessing

The initial step involved in information gathering is to pre process the information suitable for the required purpose[15-17]. Preprocessing aims to diminish the effect of noise and to blur the false contours that may be present in an image. A low pass filter (*Gaussian blur*) has been used in this work for this purpose to reduce the high frequency noise component of the image. Gaussian filter has been used in many similar type of work [18] [19] because of the typical hat like structure of the filter. This filter focuses on the central pixel by considering all the neighboring pixels depending on the size of filter. We have used 5x5 Gaussian filter, as if the size of filter is inversely proportional to number of calculations and is filter size is more than required purpose is not solved[19].

$$A^* = \frac{1}{159}\begin{bmatrix} 2 & 4 & 5 & 4 & 2 \\ 4 & 9 & 12 & 9 & 4 \\ 5 & 12 & 15 & 12 & 5 \\ 4 & 9 & 12 & 9 & 5 \\ 2 & 4 & 5 & 4 & 2 \end{bmatrix} \times A$$

Where A: input image

A*: resultant image obtained by use of filter

Result of application of Gaussian blur on a test image is shown in section 3.

2.2 Background Elimination

Binary thresholding has been carried out by initially computing the total variance of the entire image by considering all the pixels.

The total variance computed is used as an initial threshold.

$$\dot{v} = \sum_{i\in Q} \frac{(m - x(i))^2}{|Q-1|} \quad \ldots.(1)$$

where $\dot{v}$: Total variance

m : mean of the pixels in the image

x(i) : each pixel from the set of pixels Q

This threshold is optimized by using PSO algorithm. The flowchart in fig 2 shows the basic procedure of PSO algorithm [5].

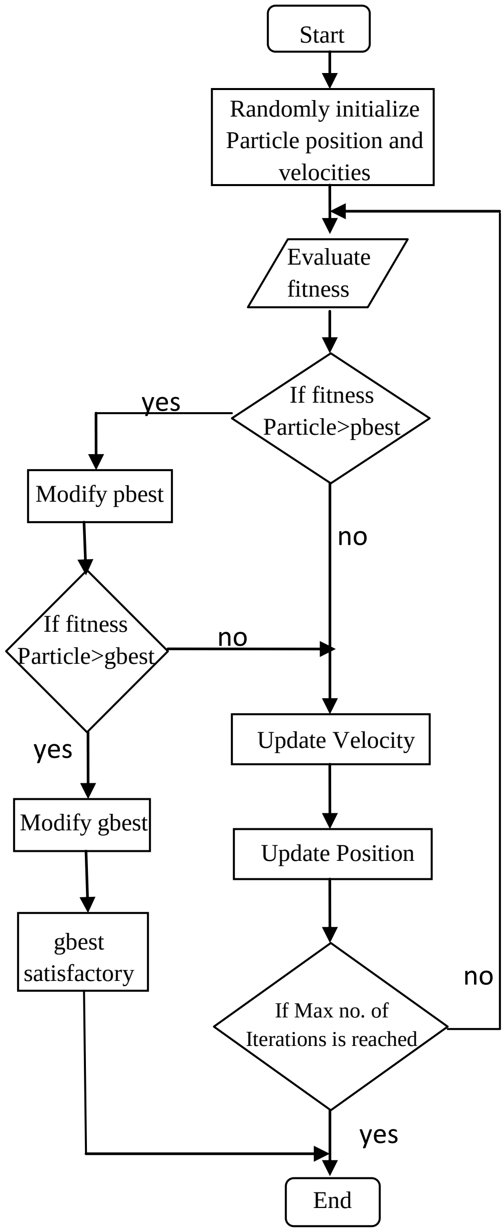


Fig 2: Flowchart of PSO algorithm.

The computed total variance is used as initial global best to start the search of threshold for binary thresholding. Foreground –background ratio (fbratio) with the initial global best is computed, fbratio is used as the feature which corresponds to the position and velocity of basic procedure of PSO algorithm.

Experimental results show that features lying in the range of $0.4 \leq$ feature ≤ 1 facilitate the work of the search by giving a measure to decide the swarm size ,described in section 3. Now all the variance among the pixels corresponding to each intensity level of a image is computed and with that variance corresponding feature is also computed.

Mean Square Error(MSE) has been used as the fitness function for updating the global best of the search

$$\text{Fitness} = \frac{1}{2}(\text{Gbest} - v_i)^2 \; . . . .(2)$$

Where v_i : variance for each intensity level i of grayscale image

The proposed algorithm for binary thresholding optimized by PSO is

- Compute total variance by using equation (1)
- Compute foreground - background ratio (fbratio) for v use it as initial feature.
- Step through all possible thresholds $t = 1 \ldots$ maximum intensity
  - Compute $v(t)$
  - Compute foreground-background ratio (fbratio) for each $v(t)$ use it as feature
- Initialize swarm size with number of thresholds with feature in range of

  $$0.4 \leq \text{feature} \leq 1$$
- Initialize Gbest of swarm with total variance of the image.
- Iterate until maximum swarm size is not reached
  - Evalute fitness of each particle in swarm by

    $$\text{Fitness} = \frac{1}{2}(\text{Gbest} - v_i)^2$$
  - If fitness of a particle and feature is greater than those previous particles then update Gbest with Pbest and update feature.
- Use Gbest as threshold to perform Binary Thresholding on the image.

Binary thresholding gives a representation to the image which can be described by a two-dimensional indicator function whose size is same as that of the original input image [3].

Let us denote the indicator function of S by $b_s(r,c)$ and define it as

$$b_s(r,c) = \begin{cases} 1 & (r,c) \in S \\ 0 & \text{Otherwise} \end{cases} \quad \ldots(3)$$

Thus $b_s(r,c)$ is a binary image where 1-pixels constitute foreground and 0-pixels constitute background. Results of proposed algorithm for background elimination are shown in section 3.

2.3 Segmentation

After binary thresholding background is eliminated from the image and foreground (region of interest) is retained in the image. This foreground is segmented into segments by using connected component concept. Each of the pixel is initialized with a same initial cluster label.

Method used for segmentation is based on the connected component labeling concept [20] to find out the connected segments . This algorithm will assign a unique label to different segments of the image so that object can be easily detected uniquely.

In this work we have consider the problem of labeling binary image stored in 2-dimensional (2D) array. There are two common ways of defining connectedness for a 2D image: 4-connectedness and 8-connectedness [21].

	Y-1	Y	Y+1
X-1	1	2	3
X	4	5	6
X+1	7	8	9

Fig 3: 8-Connected Neighborhood.

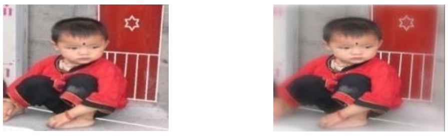
Figure 3 describes the current pixel which is to be examined (darkened) which is the middle one and the eight neighborhoods are marked as 1, 2, 3, 4, 6, 7, 8, and 9. Pixels marked 1,2,3,4 are symmetric to the pixels marked 6,7,8,9. Considering the pixel marked 1,2,3,4 of the corresponding eight neighboring of each pixel from figure 4, a horizontal scan is performed to form the clusters. Each of the connected pixels are grouped together to a group and are assigned with a unique cluster label using a label indicator (count used in proposed algorithm). During each scan pixels having a same cluster label is not examined and a new cluster with different label is formed. Cluster labels are assigned depending on the connectedness of pixels if all pixels 1, 2, 3,4 have a value of zero and pixel 5 has a value greater zero then this pixel will be the first point of different segment .In this manner the entire image is segmented. The respective color of the center pixel of a cluster from the corresponding initial unsegmented image is used to color each of the segments to differentiate among the segments having different unique color**.**

The proposed algorithm for segmentation based on the principle of connected component

- For x=1 to height of image
  - For y=1 to width of image
    - If image[x][y]=1
      - If image[x-1][y+1]>0 image[x][y]=image[x-1][y+1]
      - Else If image[x-1][y]>0 image[x][y]=image[x-1][y]
      - Else If image[x-1][y-1]>0 image[x][y]=image[x-1][y-1]
      - Else If Image[x][y-1]>0 image[x][y]=image[x][y-1]
      - Else image[x][y]=count++

3. RESULTS AND DISCUSSION

Following result was obtained by the application of the Gaussian Blur on an image .It is observed that the unnecessary false contour of background part is smoothened.



(a) **(b)**

Fig 4 : Result of application of Gaussian Blur for preprocessing.

Proposed algorithm of binary thresholding was used on various images and result observed for the following three test image 5(a),5(b),5(c) is shown .

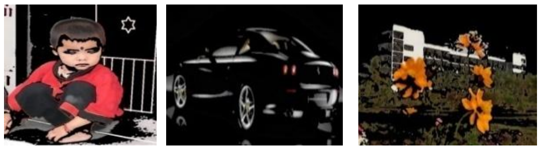
(a) **(b)** **(c)**

(d) **(e)** **(f)**

(g) **(h)** **(i)**

Fig 5 : Result obtained by binary threshold.

Figure 5(a)(a boy),5(b) (a car) and,5(c) (a building with flowers) are the test images whose foreground information is needed to be preserved. Figure 5(d),5(e),5(f) shows the corresponding result of binary thresholding using simply total variance as the threshold. In these images it can be seen that lot of foreground information is lost as the background .In figure 5(d) it can be noticed that the entire curvature of the face is not preserved such as the forehead part and the region around the eyes is missing.In figure 5(e) it can be seen that the entire shape of the car expect the wheel is lost .And in figure 5(f) it can been seen that the outer and inner curvature of the building is not regular and the curvature of the flowers is missing. Thus if these binary images are used for feature extraction ,extracted feature will not be exact and accurate. 5(g),5(h),5(i) shows the corresponding result of the binary threshold by the proposed thresholding algorithm in which threshold is optimized by PSO.In these images it can be noticed that accurate curvature of region of interest are retained.Thus providing exact features of the object of the interest.

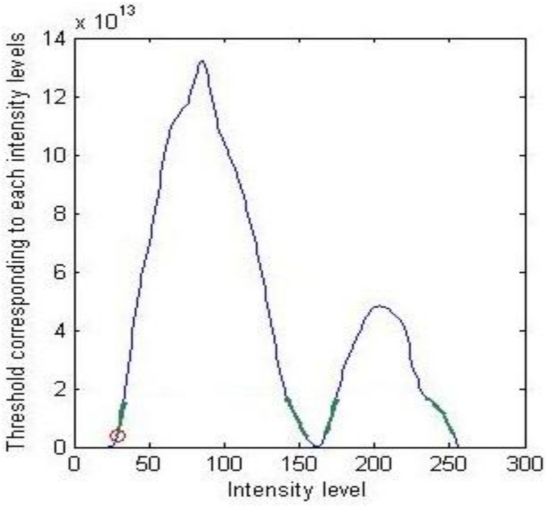


(a) **(b)** **(c)**

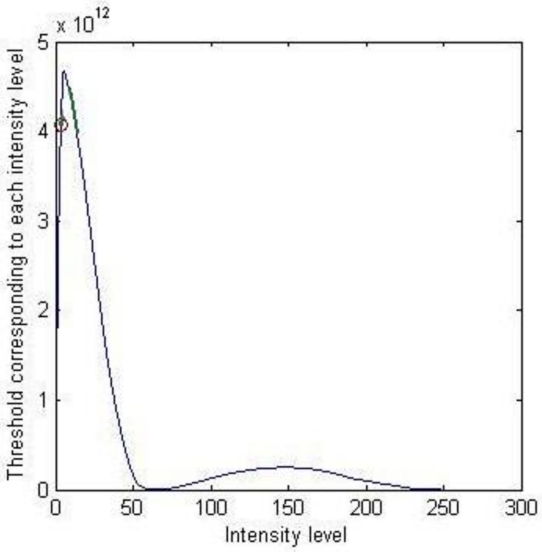
Fig 6: Result obtained for the test images by proposed algorithm of segmentation after background elimination.

Figure 6(a),6(b),6(c) shows the final result showing different segments present in the foreground of test images corresponding to the test images in Figure 5(a),5(b),5(c) respectively.

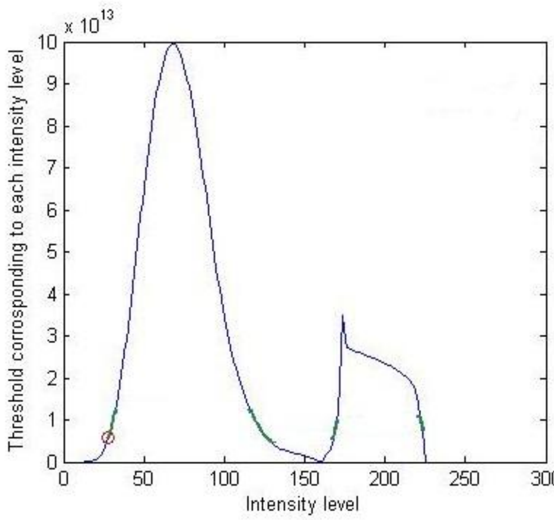
Following plots figure 7(a),7(b),7(c) show the change in the thresholds corresponding to an intensity level computed for the grayscale image of figure 5(a),5(b),5(c). repectively. All the possible thresholds is shown by the solid line,the solid line with a larger width describes the threshold choosen by the proposed PSO method which is based on the selection of feature which is found to be optimal if the corresponding fbratio lies in between a range of 0.4 to 1.Experimental results show that if the feature doesn’t lie with in this range then a significant part of foreground is being eliminated from a object.All threshold shown by blue colored plot produces the binary image .But doesn’t produce the best binary result.Search domain is reduced by specifing the range of the feature by the proposed PSO algorithm.Based on the fitness function as described by equation (2) each of the threshold is searched to find the best optimal threshold.The optimal threshold choosen in the plots is marked by a circle which has been used to threshold the test images.The corresponding outcome of using this computed optimal threshold is shown in the figure 5(g),5(h),5(i).



(a)



(b)

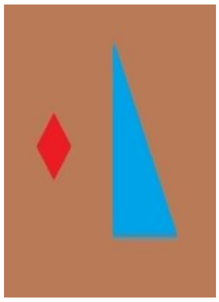


(c)

Fig 7: change of threshold corresponding to each intensity level.

In the later stage of feature extraction differentiating between foreground and background will be difficult. As the segmentation produces the segments with unique different color for each segment eliminating the intensity variances present with a segment of the image.

Proposed work eliminates this problem initially before carrying out the segmentation so that it can facilitate the work of feature extraction also as compared to other works . As it assigns a unique label to each segment which gives the following representation of an image which can be easily visualized for the following ideal image containing the geometric shapes.



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(a) **(b)**

Fig 8: Image representation to facilitate the work of feature extraction.

Figure 8(b) is the low level outcome of the input image Figure 8(a) produced by the proposed algorithm. In this representation 0 denotes the background , 1 denotes the segment-1,2 denotes segment-2 .And so depending on the number of identifiable segment present in an image.

By having a simple horizontal or vertical scan we can detect the curvature of a segment and other features such as each segment position in the image, aspect ratio of a segment.

4. CONCLUSION

The use of PSO facilitates the work of background elimination by searching the optimized threshold from the available feasible thresholds, which is a variance based approach of segmentation. Thus differentiating the foreground and background and providing a binary image for segmentation which can be easily segmented by using connected component method. The proposed algorithm also facilitates the feature extraction unlike traditional segmentation algorithms. By providing a low level representation to an input image so that feature extraction of the object of interest can be carried out easily.

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